

---

# Tevatron Instrumentation for Run II Upgrades

Jim Steimel  
DOE Review  
July 22, 2003

# Tevatron Instrumentation Priorities

---

- Monitor and control orbits and lattice
  - Changes in orbits and lattice have drastic effects on almost all critical parameters (tunes, chromaticities, coupling, beam-beam interaction, stability)
- Monitor transverse emittances
  - Low transverse emittance leads directly to high luminosity.
  - Need to identify points in the acceleration cycle with large emittance growth rates to pin-point possible mechanisms.
- Monitor and control tunes and chromaticities
  - Have a direct impact on beam stability, life-time, and transverse emittance growth rates. Will need to be tightly controlled for consistent luminosity.
- Monitor and control beam oscillations
  - Becomes highest priority if beam goes unstable.
  - Presently, beam stable with current damper systems operating at 90% final RunII design proton intensity.
- Monitor beam currents, longitudinal emittance, and losses

# Tevatron Instrumentation Projects

---

- BPM Upgrade (orbits and lattice)
- GHz Schottky Pickups (transverse emittances, tunes, and chromaticities)
- Ion Profile Monitor (transverse emittances)
- Tune Tracker (tunes and chromaticities)
- Single Bunch Pinger (tunes and chromaticities)
- Abort Gap Monitor (longitudinal emittances and losses)
- Longitudinal Damper (beam oscillations)

## GHz Schottky Pickups (WBS 1.3.4.6.7)

---

- Can see proton and pbar transverse Schottky signals above the noise floor.
- Four hardware channels have been constructed and commissioned (vertical/horizontal, proton/pbar).
- Confirmed capability of measuring transverse emittances, tunes, and chromaticities of protons and pbars at 150 GeV and 980 GeV.
- Construction of dedicated, continuous emittance monitors in progress. (Ralph Pasquinelli)
- Need to create application software to control instruments and analyze data. (Andreas Jansson)
- Commissioning to be completed by Nov '03.

## Tevatron IPM (WBS 1.3.4.5.6)

---

- Flying wires cannot give turn-by-turn profiles.
- Synchrotron light monitor works only at 980 GeV.
- Understand what happens to the emittance of protons and pbars at injection and on the ramp.
  - Need single turn resolution ( $\Delta\sigma \sim 10\%$ )
  - Should separate proton and pbar signals (by time of arrival)

## IPM Status

---

- Overall design complete (except for multichannel DAQ card).
- DAQ test stand for single channel operational.
- Vendor for magnets identified.
- MCP test stand complete in a month.
- Milestone: Internal review of project before Nov '03 to determine viability before installation.
- Multi-channel DAQ card available in ~6 months.
- Installation to occur in early 2004.
- Entire DAQ effort outsourced to PPD and CD.

## Tune Tracker (WBS 1.3.4.6.3)

---

- To track the tunes of the Tevatron up the ramp.
- To measure chromaticity and coupling up the ramp.
- To eventually use the measured tune as a feedback signal for the quadrupole controls to keep the tune fixed up the ramp.

## Status of Design

---

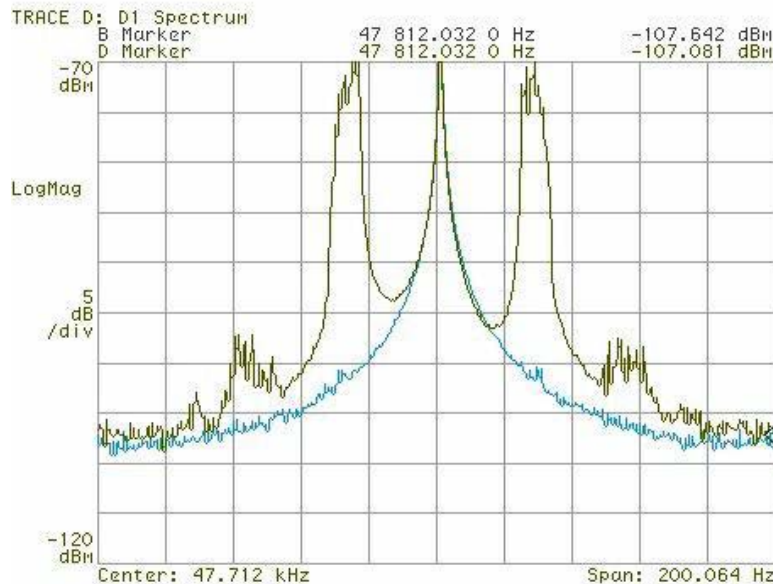
- Design involves tickling the beam and measuring the phase of the beam's response. This phase response is used to lock the tickling frequency to the betatron frequency.
- Simulations of design is complete.
- Machine studies necessary for specifying system complete.
- Prototype of DSP code complete.
- Prototype circuit-board and firmware under development.
- Est. completion and debugging of prototype hardware 11/03.
- Est. completion of software (controls integration and analysis tools) and commissioning 3/04.

## Tevatron Single Bunch Pinger (WBS 1.3.4.6.8.1)

---

- Need a reliable means of measuring chromaticity through the acceleration process.
  - GHz Schottky shows signs of trouble in early commissioning measuring chromaticity up the ramp.
  - Tune tracker still untested, under construction.
- Pinger used to stimulate head-tail oscillation in a single test bunch at injection energy and during acceleration.
- Data from head-tail oscillation measurement used to determine chromaticity.
- Proof of principle test complete for single bunch at 150 GeV.
- Pbar injection kickers are fast enough for task but we only have one plane. Need to construct/install kicker for vertical plane.

# Tevatron Longitudinal Dampers (WBS 1.3.4.6.2)



- Tevatron longitudinal dampers commissioned for protons at 150 GeV and 980 GeV.
- Dampers do not work up the ramp due to large synchronous phase angle between beam and reference RF.
- Upgrade involves constructing a beam phase-locked loop to provide a locked reference.
- Prototyping in progress by C. Rivetta (Tevatron 25% effort) with help from PPD.

## Abort Gap Monitor (WBS 1.3.4.6.1)

---

- DC beam accumulates in Tevatron during HEP. Studies show that total DC beam accumulated in abort gap is a function of longitudinal emittance growth rate.
- Need to monitor DC beam that has accumulated in the abort gap to insure clean aborts and pinpoint mechanisms for longitudinal emittance growth.
- Uses current synchrotron light monitor, gated on the abort gap.
- Will function in parallel with sync-light normal operations.

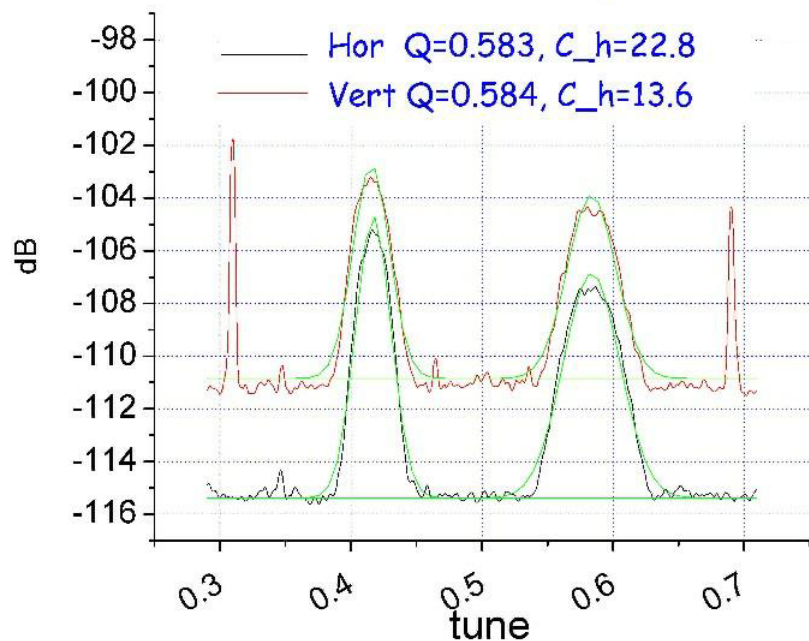
## Abort Gap Monitor Status

---

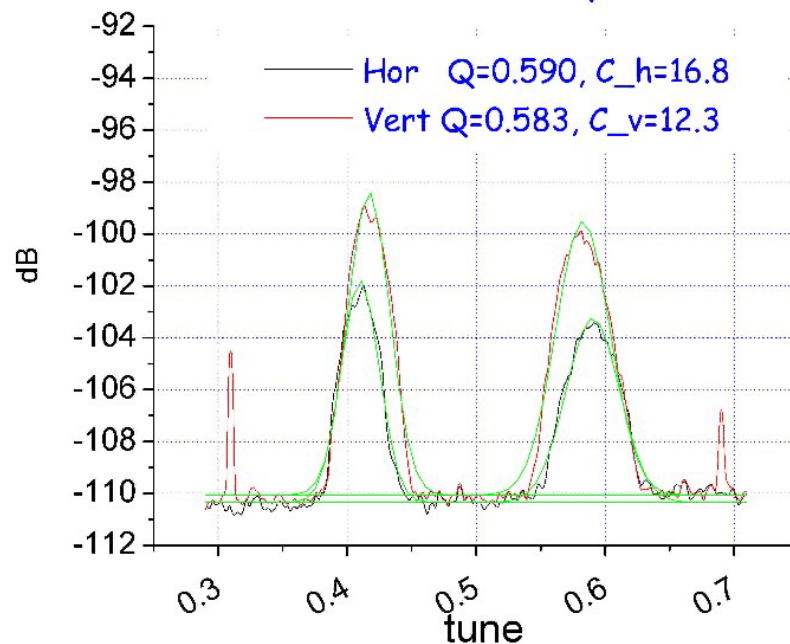
- Proof of principle complete. DC beam accumulation observed in abort gap.
- Needs more gain to observe DC beam during stores (TEL on).
- Increase voltage on MCP or install PMT and forgo 2D analysis.
- Install light shutter for more accurate “no beam” calibration of background.
- PMT hardware on hand, needs to be mounted and tested.
- Fast gated MCP may need to be procured.
- 40% of effort provided by PPD.

# GHz Schottky Pickups

2.5 hrs #2692: 1.7GHz Schottky for All Pbars

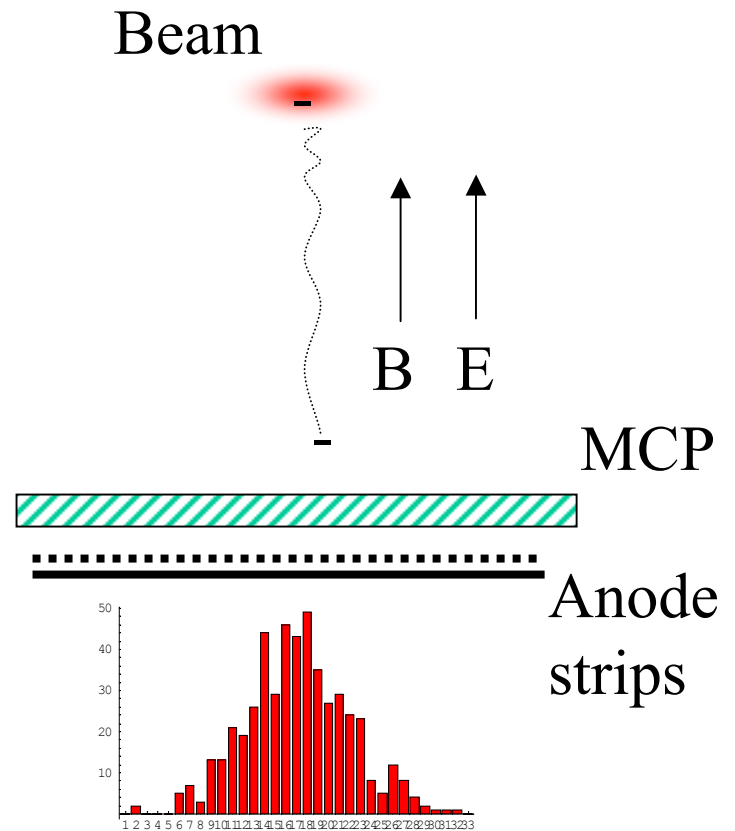


2.5 hrs #2692: 1.7GHz Schottky for All Protons



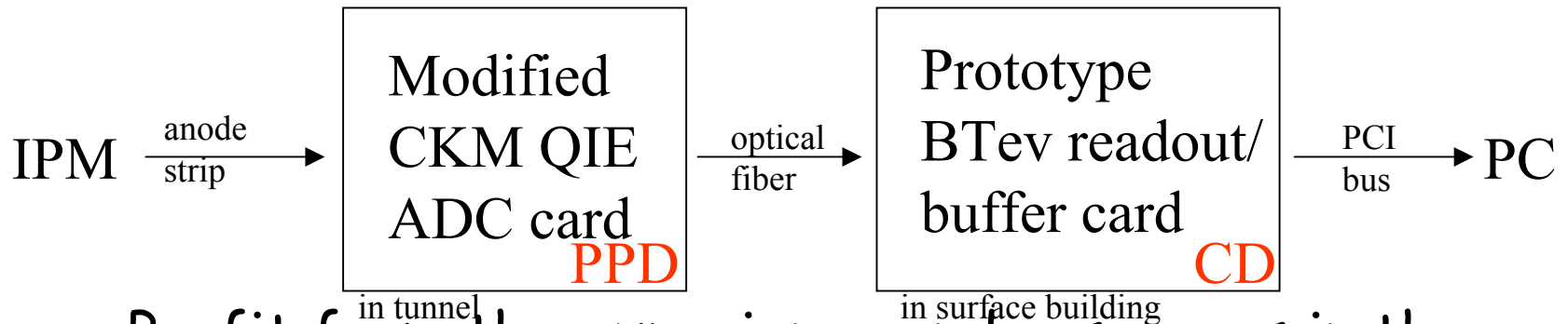
# Detector

- Modified version of MI IPM, using electromagnet to focus the ionization electrons
  - Few (~1000) electrons per bunch at normal conditions.
  - MCP gain must be kept low to avoid saturation.
  - Use low-noise electronics and digitize in tunnel.
  - Add controlled N<sub>2</sub> leak.



# Data Acquisition and Readout

---



- Profit from the experience and resources in the Particle Physics and Computing Divisions!

## Budget Estimate

---

▪ Magnets and power supplies	\$78k
▪ DAQ (QIE cards + PC readout)	\$59k
▪ Mechanical and vacuum	\$163k
▪ Estimated cost	\$300k

# Tune Tracker Block Diagram

Block Diagram of Realization

